SARACRINUS (CRINOIDEA: METACRININAE) FROM THE EARLY MIOCENE OF MOTUKETEKETE ISLAND, HAURAKI GULF, AUCKLAND, NEW ZEALAND

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Abstract. A new species of stemmed crinoid, *Saracrinus motuketeketeensis*, is described from the Early Miocene Waitemata Group, Motuketekete Island, Hauraki Gulf, Auckland. It is the first fossil record of *Saracrinus*, and the first crinoid to be described from Waitemata Group sediments. The new species has morphologic similarities with Recent *Saracrinus* spp. living in New Zealand and Indo-Pacific waters, suggesting it may be ancestral to these.

KEYWORDS: Echinodermata; Crinoidea; Isocrinidae; Metacrininae; *Saracrinus*; new species; Early Miocene; Otaian Stage; Waitemata Group; Kawau Subgroup; Cape Rodney Formation; New Zealand.

INTRODUCTION

A paucity of Cenozoic crinoid specimens exists globally (Hess 1999). A lack of appropriate facies and non-preservation of taxa are probable reasons for the scarcity. The number of Cenozoic crinoids (when present) relative to the total number of organisms in a sample, varies considerably in New Zealand. Some units of Oligocene limestone (e.g. Oteikake Limestone) contain crinoid elements in numbers similar to those of molluscs. Conversely, Early Miocene crinoid elements from sandstone at Pakurangi Point, Kaipara Harbour, are in the ratio of approximately 1:1000 molluscs (pers. observ.). Intact crinoids are exceptional in New Zealand (e.g. Stilwell *et al.* 1994), and the majority of Cenozoic crinoids are preserved as disarticulated elements. Crinoid researchers (e.g. Jagt 1999; Stiller 2000; Eagle 2003, 2004; Eagle & Hikuroa 2003) have necessarily described new species from disarticulated skeletal elements.

During a survey expedition to Motuketekete Island, Hauraki Gulf, Auckland, members of the University of Auckland Geology Department and Auckland University of Technology Earth and Oceanic Sciences Research Institute collected 70 macrofossil taxa (Campbell *et al.* in press). Echinoderms included a single crinoid specimen. The object of this paper is to identify and describe the crinoid and consider its paleoecologic, paleoenvironmental, and paleogeographic implications. Comparison with Recent specimens is made in an effort to establish its possible affinities and evolutionary relationships. The Fossil Record number listed is that of the New Zealand Fossil Record File, maintained by the Geological Society of New Zealand.

Rec. Auckland Mus. 41: 5–12 2004

GEOLOGICAL SETTING

Campbell *et al.* (in press) describe a previously unknown 2 m-thick, 30 m-long lensoidal breccia and conglomerate unit ~1–2 m above the base of the Motuketekete Limestone Member (Kawau Subgroup, Waitemata Group sediments) on Motuketekete Island. They correlate it with the regionally extensive Otaian Stage lithofacies E of Ricketts *et al.* (1989). The single crinoid described herein comes from this horizon on the south-east coast of Motuketekete Island.

The bioclastic Motuketekete Limestone Member (Hayward & Brook 1984) at the south-eastern coast of Motuketekete Island (study site R09/f151) appears (as elsewhere) coeval with Papakura Limestone and contains diverse macrofossils within the breccia. For details of the tectonic setting, stratigraphic section, and lithofacies correlations, see Campbell *et al.* (in press). This upper-breccia facies of the Kawau Subgroup is interpreted by Ricketts *et al.* (1989) as the result of an early Miocene Waitemata Basin tectonic event (e.g. earthquakes, faulting), causing down-slope debris-flows over a wide geographic area.

TAXONOMIC REMARKS

Some paleontologists have questioned whether species erected on the basis of disarticulated crinoid elements should be recognised as valid taxa under the *International Code of Zoological Nomenclature* (ICZN). Other groups of Cenozoic organisms preserved in New Zealand as disarticulated elements (e.g. vertebrates) are incorporated within a natural classification without qualification (such as done by suffixes). Stiller (2000) accepted that organisms preserved as disarticulated elements, could be classified within a more or less "natural" system without qualification. In contrast to pelmatazoan crinoids, in which the main body (crown) forms the basis for most taxonomic assignments, fragments and isolated parts of vertebrates – notably isolated teeth, bones – have often been identified and/or described (e.g. Buckeridge 1984). Donovan (2001: 888) summarised the crinoid columnal nomenclatural conundrum: "Much more effort by many more researchers has been spent classifying the relatively rare remains of vertebrates compared to crinoid columnals." This is true for New Zealand crinoids.

Since description of the Articulata in the *Treatise on Invertebrate Paleontology* (Rassmussen & Sieverts-Doreck 1978) papers detailing both fossil taxa (e.g. Oji 1990; Meyer & Oji 1993) and Recent taxa (e. g. Bourseau *et al.* 1991) have described whole specimens. It has become more practical, even "generally relatively straight-forward to classify Post-Palaeozoic crinoid columnals to family, genus, or, not uncommonly, species level, in contrast to those of the Palaeozoic," (Donovan 2001: 888) due to the limited morphological diversity shown by crinoids following the end-Permian extinction (Foote 1996). Hence, there are many systematic studies of crinoids that rely on disarticulated columnals and other ossicles (e.g. Stiller 2000). The ability to link Cenozoic and Recent dorsal cups and crowns and other skeletal elements to genera (and often species), enables systematists to place new crinoid taxa based solely on columnals with confidence within a "natural" taxonomic system.

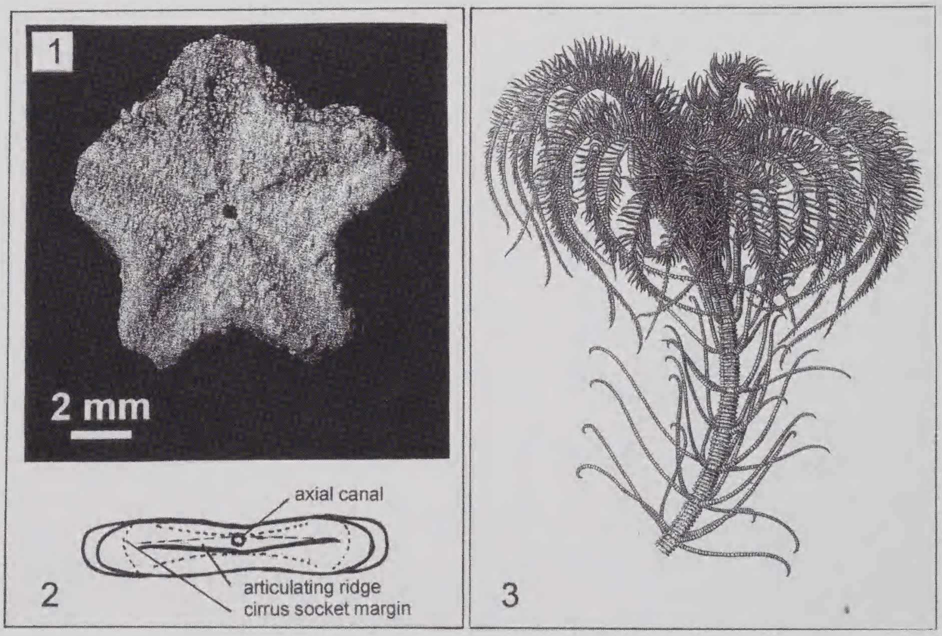
For fossil crinoids, selective preservation of skeletal elements like the calyx, brachials, or columnals, greatly reduces the range of characters available for identification compared to extant material. Based on disarticulated skeletal elements, a fossil crinoid species will always be a morphospecies, but will ideally conform as closely as possible to the limits expected of a "natural species" (Simms 1989). In this study, crinoid skeletal elements were included within the systematics of an extant genus.

SYSTEMATICS

PHYLUM: ECHINODERMATA Bruguière, 1791
SUBPHYLUM: CRINOZOA Matsumotu, 1929
CLASS: CRINOIDEA Miller, 1821
SUBCLASS: CLADIDA Moore & Laudon, 1943
INFRACLASS: ARTICULATA Miller, 1821
ORDER: ISOCRINIDA Sieverts-Doreck, 1952
SUBORDER: ISOCRININA Sieverts-Doreck, 1952
FAMILY: ISOCRINIDAE Gislén, 1924
SUBFAMILY: METACRININAE Roux, 1976
GENUS: *Saracrinus* Clark, 1923
Type species: *Saracrinus nobilis* (Carpenter, 1884) (by original designation; Recent, Indo-Pacific).

Diagnosis: Isocrinid with column pentagonal or pentalobate to rounded subpentagonal; 5–13 internodals in medial and distal stem sections, fewer proximally; nodals larger than internodals; columnal articulum with short crenulae; internodals with 5 large elliptical to circular cirrus sockets facing outward or slightly upward; cirri long (after Clark 1923; Roux 1981).

***Saracrinus motuketeketeensis* n. sp. (Figs 1, 2, 4)**



Figs 1–3. 1–2. Holotype of *Saracrinus motuketeketeensis*, E657. 1. Distal nodal articulum (reproduced from Campbell *et al.* in press). 2. Diagram of nodal latera with cirrus socket detail. 3. Life illustration of Recent *Saracrinus cingulatus* (from Carpenter 1884) showing how *Saracrinus motuketeketeensis* might have looked in life.

MATERIAL

Holotype. Specimen number E657, collection number AU17529 (paleontological collections, Geology Department, University of Auckland); pentalobate nodal with proximal (partially covered by matrix) and distal articula; latera with elliptical cirri sockets.

TYPE LOCALITY

Fossil Record File number R09/f151; grid reference R09/727238 (1989, NZMS 260, 1: 50 000 topographical map); Motuketekete Island, Hauraki Gulf, Auckland; coastal rock exposure above tide line, south-eastern shore. Fossil locality R09/f151 represents a boulder to cobble breccia and conglomerate lens c. 1.5 m above the base, but within bioclastic Motuketekete Limestone.

DESCRIPTION OF HOLOTYPE

Nodal outline bluntly stellate; proximal articulum symplectial; areolae elongate-ovoid, base convex; interradial areas raised, each petaloid bordered by dissected ridge to form crenulae; petal crenulae about 15, variable in shape and size, rather short, located on areolae margins, turned slightly inwards, large distal crenulae reach columnal periphery, smaller proximal crenula adjacent to each other in interpetaloid spaces, rounded overall, merging with open, large roughly triangular interradial area; perilumen raised, apparently smooth, same height as top of crenulae; lumen outline subpentagonal, medium sized; nodal distal articulum synostosial with similar petaloid arrangement; columnal latera smooth; 5 large, broadly elliptical cirrus sockets directed outward and slightly upward, encroaching both infranodal and supranodal joints; central, circular axial canal sited above prominent obliquely triangular articulating ridge covering two-thirds width of each cirrus socket. Measurements (mm): Diameter 10.3; height 2.4.

AGE

Otaian (Aquitanian), Early Miocene (Hayward & Brook 1984; Ricketts *et al.* 1989).

ETYMOLOGY

Named after the type locality, Motuketekete Island.

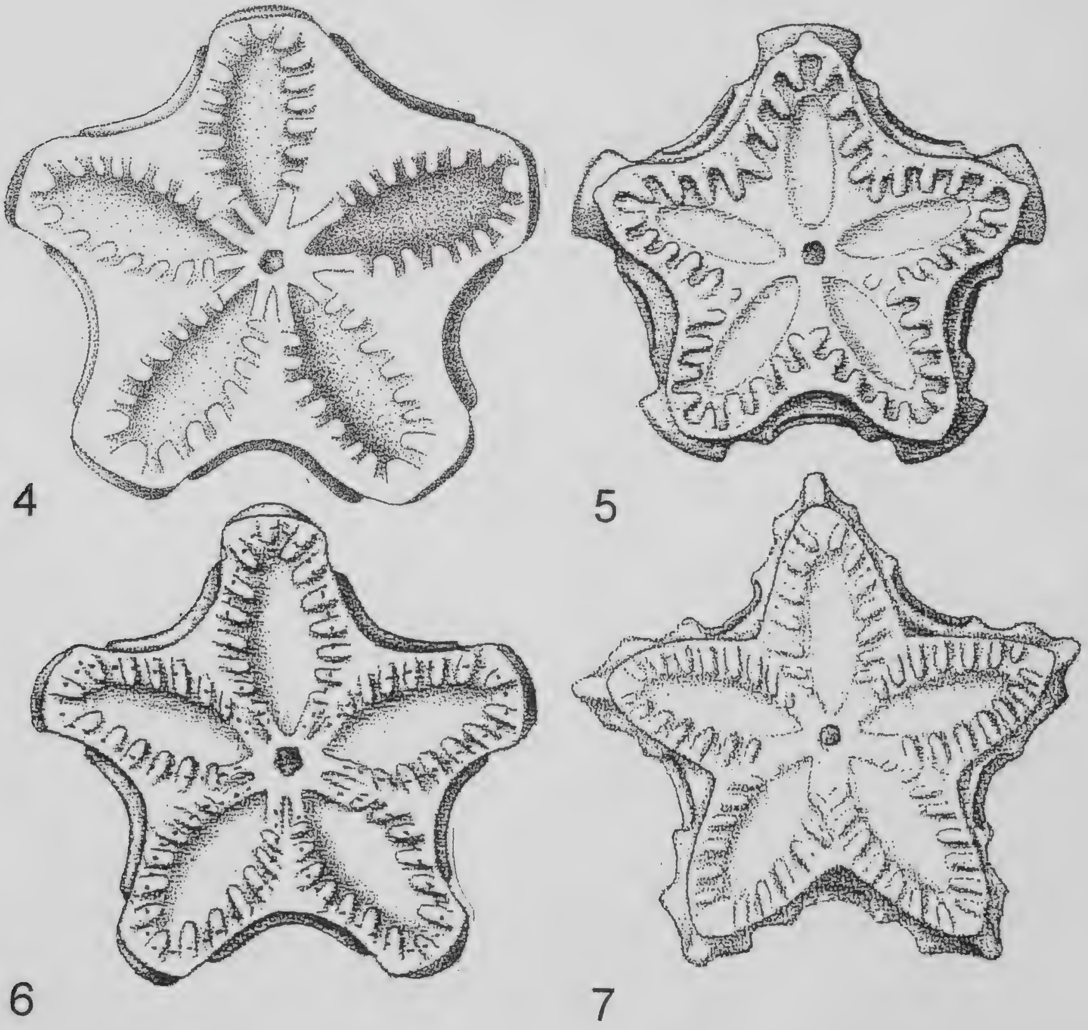
REMARKS

Abrasion of the specimen appears to be the result of post-mortem transportation. The cryptosymplectial articulated specimen is similar to *Isocrinus*, but differs in possessing more elongate areolae, having each petaloid with crenulae constructed from a dissected ridge and not from individual, isolated crenulae, and cirri sockets that are more elliptical laterally and have a longer, more obliquely triangular articulating ridge. The form of the (isocrinid) articulum appears to place this in *Saracrinus* Clark, 1923, confirmed by Roux (1981) as a valid genus. *Saracrinus motuketeketeensis* is similar in nodal articula and cirrus socket arrangement to three Recent saracrinids, *S. cingulatus*, *S. angulatus*, and *S. nobilis*, the latter being most similar in morphology (Figs 3, 5–7). However, although columnal size is about the same for all four species (c. 10 mm), *S. motuketeketeensis* differs from all three by having more crenulae (15 compared with averages of 10, 14, and 13 respectively). It is also less embayed at the interradial margin, possesses a much larger, more open interradial triangular area, and is wider radially.

Saracrinus is an Indo-Pacific genus recorded living southeast of Japan (Clark 1908), north and south of New Zealand (McKnight 1973, 1977), in seas surrounding the Philippines (Roux 1981), and Indonesia (Breimer 1978). *Saracrinus* is known from eight Recent species (Roux 1981): *Saracrinus nobilis* (Carpenter, 1884); *S. acutus* (Döderlein, 1907); *S. angulatus* (Carpenter, 1884); *S. batheri* (Clark, 1909); *S. cingulatus* (Carpenter, 1884); *S. suluensis* (Döderlein, 1907); *S. superbus* (Carpenter, 1884); *S. varians* (Carpenter, 1884). Only two *Saracrinus* species are recorded from New Zealand waters (McKnight 1973, 1977; McKnight *et al.* in press): *S. nobilis* and *S. varians*, the later described from the Kermadec Islands.

PALEOECOLOGY, PALEOENVIRONMENT, PALEOGEOGRAPHY

Bathymetric distribution of isocrinids is today constrained by ecologic parameters, primarily temperature, but also pressure, salinity, and water energy. At the specific level, they are generally eurybathic rather than stenobathic. Isocrinids are typical inhabitants of the continental slope



Figs 4–7. Proximal nodal articula of fossil and extant *Saracrinus*. Not to same scale. 4. *S. motuketeketeensis* (reconstructed). 5. *S. cingulatus*. 6. *S. nobilis*. 7. *S. angulatus*. (Figs 5–7 from Carpenter (1884)).

upper zone, with most living at depths of 200–1000 m. The bathymetric range of suspension-feeding *Saracrinus* extends above and below this (55–1152 m). They live on the continental shelf, continental slope, submarine volcanic slopes (e.g. Kermadec Islands), submarine ridges (e.g. Norfolk Rise) and ocean banks (e.g. Wanganella Bank). Because of similar morphology, it is probable that the Early Miocene species *Saracrinus motuketeketeensis* existed at a similar depth and in a similar environment to that of Recent *Saracrinus*. Recent *Saracrinus* is a tropical to warm-temperate genus, but was sub-tropical in the Late Oligocene to Early Miocene. Like most isocrinids, *Saracrinus* appears to lack a diurnal rhythm, and is postulated to feed almost continually (Breimer 1978). Recent *Saracrinus* is a moderate rheophile that anchors (depending on benthic conditions) by radicular cirri and terminal radices that penetrate a sandy or muddy substrate to provide a holdfast, or (being an isocrinid) uses radicular cirri to grasp shelly and rocky substrates (Breimer 1978).

Additional to "plankton rain" captured passively, *Saracrinus* also uses a brachial, parabolic filtration fan that uses water currents for food supply. It is probable that this feeding mechanism was the same for the Miocene Motuketekete Island species. *Saracrinus* is able to relocate to better feeding sites, or away from excessive water energy by dropping onto and crawling along the substrate prior to re-erection in the feeding posture. *Saracrinus* dislikes turbidity currents, requiring aerated, clean, clear water to prevent 'choking' and for respiration. Strong currents are known to prevent the erection of stemmed crinoid filtration fans for feeding and to break erected columns.

Given the faunal assemblage, the Motuketekete Island *Saracrinus* was likely to have been an itinerant species living at inner shelf depths on sand, shell, and rock (probably out-washed coastal cliff talus) associated with a diverse community of shallow- living, warm-water, marine invertebrates. The mixed assemblage of mainly filter-feeding animals included the corals *Turbinaria* and ?*Alveopora*; sponges of unknown affinity; the cidaroid *Stereocidaris*; bryozoans; the brachiopod *Magasella*; the gastropods *Sarmoturbo*, *Bolma* and *Tropicolpus*; the bivalves *Anomia*, *Chama*, *Crenostrea*, *Grandaxinea* and *Eucrassatella*; the barnacles *Armatobalanus*, *Tasmanobalanus* and *Bathylasma* (with acrothoracican borings); and several growth forms of rhodoliths (Campbell *et al.* in press).

Hess (1999) explains the non-occurrence of *Metacrinus* and other isocrinids in southern ocean waters today as due to the development of the cold circum-Antarctic current in the Late Oligocene, and subsequent decline of sea temperature to below a level at which they could survive. *Saracrinus* may have been similarly affected, or alternatively, never migrated to such high latitudes. Early Miocene *Saracrinus* living in marginal-tropical New Zealand waters of that time (equivalent to the geographic position and latitude of the Kermadec Islands today) probably occupied the same tropical ecological niche that it does presently. However, it is suggested that *Saracrinus* may have been forced to survive cold Pliocene periods and Pleistocene ice ages by adaptation to temperate Pacific waters or by reciprocal migration, which may explain its Pliocene-Pleistocene absence from New Zealand.

DISCUSSION

Roux (1981: 512, fig. 10) postulates that *Metacrinus* evolved from *Cenocrinus* during the early Tertiary, and that *Saracrinus* radiated from *Metacrinus* sometime during the middle to early Late Tertiary (the lineage arising from *Isocrinus*). The evolutionary postulation of Roux (1981) is supported by *Metacrinus* occurring fossil Palaeocene to Oligocene in New Zealand (Hess 1999) and by the Motuketekete Island *Saracrinus*, which may also be an ancestor of saracrinids presently living regionally. The specimen is the first fossil record of *Saracrinus* in New Zealand.

Acknowledgements. I thank Jack Grant-Mackie (University of Auckland) for making available the Motuketekete crinoid as well as suggesting improvements to the draft manuscript. Thanks are also due to an anonymous referee for valuable amendments, and to Louise Cotterall (University of Auckland) for the digital image of the fossil specimen. The Auckland Museum supported both research and publication.

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